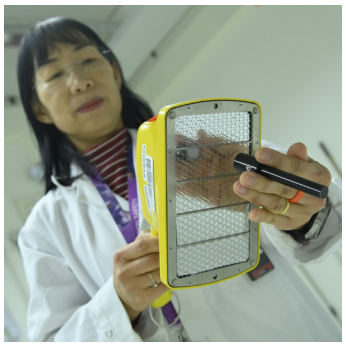
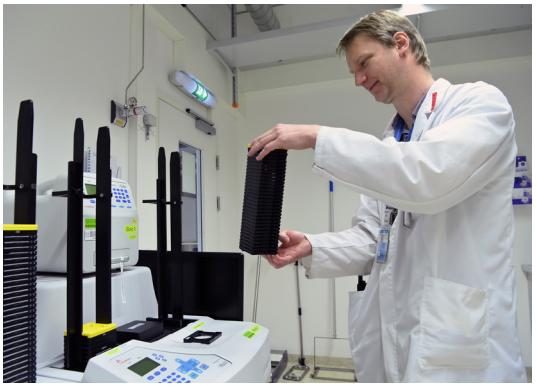


Decision-Making at Very Low Doses

Radiological Protection Working Group





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Decision-Making at Very Low Doses

Overview

This technical report, prepared by the World Nuclear Association's Radiological Protection Working Group, supplements the Association's existing position statement on Managing Low Dose Radiation Exposure [1]. It examines the challenges associated with decision-making in situations where doses and any associated risks are extremely low, and explores approaches for achieving more proportionate outcomes in such cases

The challenge

The current approach in the system of radiological protection supports and encourages unjustified allocation of society's resources on negligible radiological impacts. These resources can take the form of public funds, regulatory effort, and industry resources for example, with downstream effects in areas such as energy prices, job creation, and sustainability factors such as the ability (or lack thereof) to reasonably recycle materials. This is detrimental to society as a whole.

Radiation exposures from planned exposure situations, specifically in relation to the public, are often a fraction of those of natural background radiation. At these levels there is a high level of uncertainty in radiation risk estimation. Given this uncertainty and acknowledging the fact that all human life takes place in a variable natural background radiation that generally dominates these lower dose exposures, decisions related to control need to be proportionate and follow a graded, risk-informed approach.

World Nuclear Association therefore proposes that the current regulation of exposures at very low doses is not appropriate, and that decision-making processes should be modified accordingly.

What is ‘low dose’ and ‘very low dose’?

The definition of ‘low dose’ is often based on epidemiological outcomes on risk from radiation. There is evidence that at doses above 100 mSv there is a direct relationship between dose and risk – essentially linear in nature – but at levels below this dose the risk picture is much less clearly defined. Hence some international organizations regard a dose below 100 mSv [usually expressed as 100 mGy of low LET (linear energy transfer) radiation at a low dose rate] as a ‘low dose’ [2].

Consideration of ‘very low dose’ should take into account the radiation from naturally occurring sources. The worldwide average dose from natural background radiation is about 3 mSv/yr [3], although this can be highly variable, ranging up to many tens of mSv/yr, and even up to a few hundreds of mSv/yr .

Human-made exposure situations that result in very low doses make little or no significant difference to the total exposure of any individual. Indeed, the individual decisions made in normal life, without any personal understanding of radiation, such as where to live, where to go on holiday, what foods to eat, or how to travel, often result in higher radiation exposures than the very small contributions from many regulated activities. Knowledge of the universal existence of this background exposure, which is essentially unique for radiation compared to other risks, is potentially vital to aid public understanding of radiation exposure. Understanding natural background radiation is vital because it provides context for doses from human activities.

The choices made in normal life can result in increases in natural background exposure levels much larger than some very low dose exposures from regulated activities. However, while strict controls are placed on much smaller doses from artificial or human-made sources, there is little effort to control these much larger doses from natural sources. This can lead the public to regard very low dose human-made exposures as more dangerous than exposure to natural sources. This emphasises the need for more public awareness of natural radiation exposure and a more equitable approach to all very low dose exposures. Balancing precaution and risk is multidimensional, requiring judgement and assessment to avoid an overly simplistic and unrealistic approach of mandating zero risk.

For the purposes of this discussion, very low dose is defined as dose that makes at most a marginal difference to the total dose to an individual; in other words, that it is so small that it is subsumed in the noise/variability of natural background exposure. On this basis very low dose covers the range of a few tens of μSv/yr, up to a maximum of a few mSv/yr.

Radiation risk at very low doses.

As noted earlier, there is clear epidemiological evidence of health risk at exposure levels above 100 mSv (cumulative or acute incremental doses beyond natural background radiation).

Below this dose level there is much more limited and less consistent evidence of health risk from radiation, although there is some limited scientific evidence that risks may be present at levels down to a few tens of mSv. The current generally accepted approach to radiological protection is based around a working model termed the linear no-threshold (LNT) approach, which postulates that there is a linear relationship between risk and dose across the entire dose range – *i.e.*, the linear risks identified through epidemiological studies of populations with relatively high doses above 100 mSv are reverse projected across all lower doses, even down to zero. This approach has been used purely to provide a basis for the system of radiological protection and is not claimed as a scientific theory.

At very low dose – typically at the sub-mSv level, there is no clear scientific evidence of risk. At these lower doses, risks of health effects are either too small to be observed or are non-existent. Indeed, should some residual risk exist even at these very low dose levels, this level of risk would be extremely small, particularly relative to the risks of everyday life.

An alternative model to the LNT approach is the 'threshold model', where there is a threshold dose below which there is no risk. In addition, there is some scientific support that very low radiation doses are protective and even reduce overall health risks – a theory termed 'hormesis'. These alternative approaches are the subject of ongoing debate and discussion.

In World Nuclear Association's 2022 position statement on *Managing Low Dose Radiation Exposure* [1], the Association considers that there is inadequate scientific support for the widespread application of the threshold model or the hormesis approach, and hence the Association accepts that the LNT-based approach is the best current approach for developing an RP system. However, at very low doses (as defined in this text) where the assumed detriment or harm is extremely low, both the magnitude and the uncertainty surrounding any associated risk has not been adequately considered, leading to disproportionate use of resources to control these very low doses.

Hence whilst the Association supports the use of the LNT approach for practical radiation protection purposes, it also advocates for consistent application of the graded approach and proportionality be integrated into assessment and decision-making processes at very low doses, where the LNT approach is not a reliable indicator of risk/harm.

Given this uncertainty over whether there is indeed any risk at these very low radiation levels, together with the fact that all human life is lived within a variable natural background radiation field, decision-making around such very low doses should recognize the overall context of the uncertainty of any associated risk, and that if indeed there is a risk, it is at most comparable to risks generally accepted in society. Any human-made exposure at such a very low dose would be relatively small compared to the normal variation of doses to people from natural background radiation. This concept is the focus of this report. It is important to ensure that decisions regarding very low dose practices reflect the overall context of any possible risk, and its situation alongside natural background exposures. It is also essential to ensure that the resources allocated to radiological protection provide reasonable value to society and are proportionate to the actual risks..

Risk-based decision-making

Generally, in the health and safety field there is an acceptance that controls should be proportionate to the risk. We must avoid the drive towards 'ever lower doses' and minimization of exposure.

The ICRP recognizes the need to ensure that societal resources are not wasted [4]:

> *"There is an expectation, deriving from principles of good governance, that the application of radiological protection regulations will consider what is justified to avoid harm and the optimal use of societal resources. Governments have obligations not to allow societal resources to be squandered on unproductive legislation and fruitless regulatory control, and not to limit individual freedoms (Phillips, 2006). The stringency of regulatory requirements placed on an activity should be commensurate with the scale of risk arising from the activity."*

Unfortunately, this statement has not received much visibility or promotion and has often been ignored in practice. There are many examples where regulations result in outcomes where human-made exposures are required to be less than natural background levels – despite the expense and level of effort being disproportionate to any theoretical benefits. Such an outcome reinforces the perception that human-made radiation is more dangerous than natural radiation.

Furthermore, by emphasising the risk of very low dose exposures solely based on LNT, the view that there is no safe level of radiation is reinforced. Promoting interventions, particularly those disproportionate to the risk, at very low dose levels can serve to increase public fear of radiation – often referred to as 'radiation phobia'.

Examples of decision-making at very low dose

In the late 1980s the International Atomic Energy Agency (IAEA) published recommendations on establishing rules and guidance at very low dose [5]. Two fundamental considerations were applied to the concept of whether a risk or dose was 'trivial', relating to whether risk levels were likely to be acceptable to individuals, together with using natural background as a reference level. For both considerations it was concluded that 'trivial' could be regarded as "some tens of microsieverts per year", equivalent to a few percent of natural background.

World Nuclear Association views this range as overly conservative. The radiation risk factor was derived purely on the basis of the LNT model with no recognition of the uncertainty at such a low dose level. In addition, the 'few percent' of natural background is quite restrictive in comparison to the actual variation in both background radiation levels and dose from normal day-to-day decisions as discussed earlier.

This recommendation on what is considered 'trivial' was then applied as the basis for assessing clearance levels – where radioactivity levels of materials are sufficiently low that they can be released from regulatory control. This required a set of modelling dose assessments to convert the trivial dose level to measurable activity concentration (in Bq per gram) for each nuclide. This modelling process was extremely conservative such that in most cases the actual dose received in the clearance process is around one to two orders of magnitude less than the IAEA recommendation of ten of microsieverts per year – *i.e.*, doses actually received by workers in the recycling industry are likely to be in the range 0.1 to 1 μSv/yr [6]. Indeed, the clearance criteria are so unnecessarily restrictive that much material that could be released for reuse and recycling (especially during decommissioning activities) must be retained in the system as radioactive waste at considerable expense to society and against 'sustainability' considerations that encourage the minimization of waste and the reuse of materials.

ICRP perspective on natural background radiation

The current system of radiological protection addresses natural background exposures, which are termed 'existing exposures', under a completely different approach than those from human-made planned exposure situations (often termed 'practices').

Based on the difficulty of controlling natural background exposure, such exposures up to around a few mSv/yr are essentially deemed to be acceptable, and activities which result in exposure modification within this range (such as dietary choices, the mode of travel (*e.g.*, air flights and holiday location choices) are not regarded as worthy of further control.

The system of radiological protection should be clear and relatable to members of the public and it should therefore avoid a major dichotomy in approach in areas of particular public interest – such as the different approaches for low dose natural background exposure and other very low dose exposures that may affect the public (as illustrated above). Major differences in approach to exposures at the same very low dose level present a particular challenge to public understanding.

Optimization of protection

In optimizing risk, due account should be taken of all types of risk related to the activity – *i.e.*, there needs to be a more holistic approach to optimisation, accounting for risks other than radiation. There are examples of situations where the implementation of measures to achieve very low radiation dose levels exposes people to greater risk from conventional risks compared to the saving on radiation risk – *i.e.*, the decision to implement controls to achieve a very low dose of radiation increases the overall level of risk [7]. One such example comes from environmental monitoring under Canada's Metal and Diamond Mining Effluent Regulations [8]. Mandated lethal fish sampling programmes, which include radionuclide sampling, have been estimated to have sacrificed over 60,000 fish nationwide since 2002 — nearly twice the recommended guidance. In some cases, this sampling causes more harm to fish populations than the mine effluents themselves, illustrating how efforts to minimise one form of risk can inadvertently increase overall environmental harm.

The Association supports the *IRPA Perspective on 'Reasonableness' in the Optimisation of Radiation Protection* [9], which emphasises:

The need for proportionality

The resources allocated to optimization should be proportionate to the level of risk.

Avoidance of over-conservatism

It is very important that optimization processes are based on realistic assessments of risks and benefits, including radiation dose assessments and other relevant risks. The use of multiple conservative assumptions in assessments, which result in significant over-estimates of exposure, or the use of 'worst case scenarios', are a misinterpretation of reasonableness and can lead to a misallocation of resources.

De minimis approach

Some consideration should be given to the concept of a practical cut-off, below which no further efforts to address optimisation are necessary. Over recent times various proposals for such a practical cut-off have covered the range from 10 μSv/year up to doses around 5-10% of the relevant worker or public dose limit. Whilst this approach is understandable and has considerable rationale, it is challenging to apply in practice. It is none the less appropriate to consider how the underpinning conceptual value of this approach could be implemented in a more practical way. Authorities and regulatory bodies should have a very careful regard before setting expectations or requirements for optimisation assessments at low doses, unless there are significant and very specific reasons for doing so. This approach should apply particularly where exposures are significantly below relevant limits, constraints, or reference levels – which of course would be a matter of judgement, and which could benefit from wider consideration. Such a course would align with the concept of a graded approach and support the effective use of society's resources.

Conclusions and recommendations

- During the ICRP's current programme to review the system of radiological protection, several issues that have been consistently raised by many practitioners are mainly focused on two principal challenges:
  - The need for a system of protection that is understandable and more relatable to the public, and which does not contribute to reinforcing public concern and radiation phobia.
  - The need to deliver good value for the use of society's resources.
- The approach to very low dose exposures that can impact the public should cover – in a consistent way – both natural background exposure and relevant practices (planned exposures).
- In making decisions regarding very low doses, the uncertainty that exists in risk estimates at these levels should be acknowledged, and the LNT approach should not on the only input to decision making.
- Decision-making should consider "optimal use of societal resources" and give due regard to not allowing "societal resources to be squandered on unproductive legislation and fruitless regulatory control", as stated by the ICRP. Such statements should be given a higher profile in the next ICRP General Recommendations and in major publications of other relevant international bodies.
- Further consideration should be given to the identification of a dose level (perhaps in the region of a few tens of μSv/yr) below which exposures are considered to pose no significant harm to an individual worthy of further resource allocation or significant regulatory interest, below which 'special justification' should be required to support any further intervention in the dose control regime.

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